The effect of simulated warming ocean temperatures on the bacterial communities on the shells of healthy and epizootic shell-diseased American Lobster (*Homarus americanus*).

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American lobster (*Homarus americanus*)

Marine crustaceans

Ecological impact not well studied in all lobster species
- Mid-trophic level: push energy from primary producers up the food chain
- Scavenge detritus / turnover decaying material

Molt their shells to grow

Up to 100 year lifespan

Image: https://www.fisheries.noaa.gov/species/american-lobster

Pronunciation guide: “lob-stah”

Atlantic lobster industry

Image: https://www.fisheries.noaa.gov/species/american-lobster#commercial

Image: penbaypilot.com/article/lobster-catch-maine-down-southern-new-england/57279

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North Atlantic lobster industry

American Lobster Landings by Stock Area

- Gulf of Maine/Georges Bank
- Southern New England

Source: Atlantic States Marine Fisheries Commission

Image: penbaypilot.com/article/lobster-catch-maine-down-southern-new-england/57279
Warming coastal waters pushing lobsters north

Source: https://www.climate.gov/news-features/climate-and/climate-lobsters
Epizootic shell disease (ESD)

Causative agent(s) unknown

Causes pitting or softening of the shell
- Is not known to kill a lobster directly
- Increases susceptibility to infection, predation, physical damage

Advancing rapidly in wild populations
- Connection to ocean warming?

Image: https://www.vims.edu/research/departments/eaah/programs/crustacean/research/lobster_shell_disease/
Experimental design

57 female lobsters collected from southern Maine coastal waters

Management zones F, G
Experimental design

Lobsters were assessed for visible shell disease and scored by percent of shell covered (Smolowitz et al., 2005)

- 0, no observable signs
- 1, on 1 - 10% of shell
- 2, on 11 - 50% of shell
- 3, on >50% of shell

Image: Deborah Bouchard

Created with BioRender.com
Experimental design

Lobsters were placed into separate tank systems based on

A) Apparently healthy
B) Shell Disease Index 1 - 3

Lobsters housed in individual tanks
Experimental design

2 weeks of adaptation

Baseline sampling (summer)
- Tank water a 11°C

4 months later (winter)
- Tank water respective to regional simulation

10 months later (summer)
- Tank water respective to regional simulation
Experimental design

Samples collected at 3 timepoints
- Shell bacterial community, lobster weight, lobster length, Shell Disease Index

A designated portion of the shell was swabbed to sample shell-associated microbial community
Experimental design

131 experimental samples, plus 10 controls:
- PCR amplification and purification,
- Illumina MiSeq ver. 4 sequencing,
- passed quality-control filtering.

Sequences were processed using the R software platform, using DADA2, phyloseq, vegan, and assorted other packages.

Created with BioRender.com
Bacterial richness on shells was same at baseline (as expected)

All lobsters collected from same location

Baseline is 2 weeks after collection, all at 11°C

Point shape = location the tank temperature will mimic
Bacterial richness on shells affected by tank temperature

After 4 months in tanks, all lobster shells hosted fewer bacterial taxa

Starting to see differences by simulated geographic ocean temp
After 10 months, lobster shells in warmer water host fewer different bacterial taxa
Lobster shell bacterial community richness in warmer water were less variable
Tank temperature affects “who” is found on lobster shells

Distance calculated with unweighted Jaccard similarity
- only considers the presence or absence of a bacterial taxa, not how many of that taxa might be present
Tank temperature affects abundance of each bacterial taxa found on lobster shells

- Winter, 4 months
- Summer, 10 months
- Baseline

Distance calculated with weighted Bray-Curtis similarity:
- considers the presence/absence of a bacterial taxa
- AND how many of that taxa might be present (abundance)
Subtle changes to the bacterial community in healthy vs. epizootic shell diseased shell
Broader impacts of this work

New England lobster industry survey:

- Been lobster fishing for decades
- Most have significant financial investments in their business (personal funds, loans)
- 9 - 36% have not finished high school
- In Maine especially, few local economic alternatives


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